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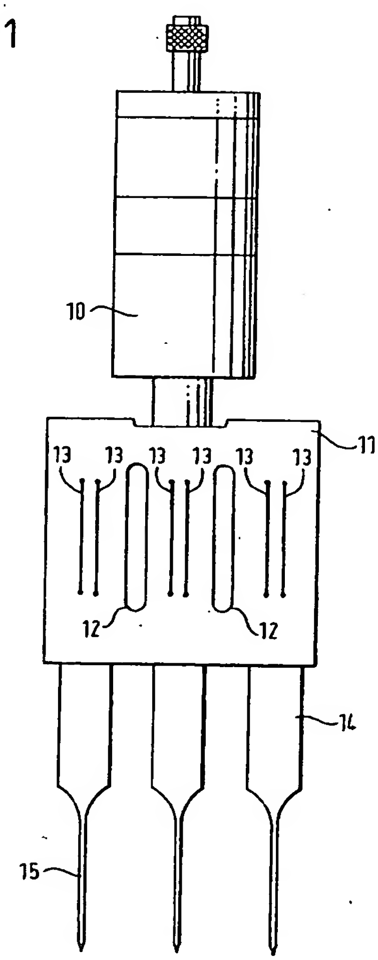
(54) Ultrasonic cutting system

(57) An ultrasonic cutting system comprising an ultrasonic vibrating device having an operative face, a block horn having a responsive face connected to the operative face of the ultrasonic vibrating device and an operative face and being provided with at least one normal tuning slot having a width of from 4 to 6mm traversing the block between its operative and responsive faces, a plurality of cutting blades mounted on the operative face of the block horn so as to be vibrated thereby/therewith, the blades lying in a plane containing the longitudinal axis of vibrations characterised in that the block horn is also provided with at least one thin tuning and damping slot having a width of from 0.1 to 2.5mm traversing the block horn between its operative and responsive faces.

FIG. 1



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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a cutting system and particularly to an ultrasonic cutting system.

BACKGROUND OF THE INVENTION

[0002] The conventional method of ultrasonic cutting involves the use of a cutting blade which is mounted on an ultrasonic vibrating device with the blade lying in a plane containing the longitudinal axis of vibrations, and moving the blade through the article to be cut in said plane. However, difficulty is experienced using such conventional methods in that the depth of the cut which is attainable is limited. For this reason, ultrasonic cutting has in general been limited to thin articles such as paper, cloth and thin plastic sheets. Significant problems exist in cutting blocks of substantial depth, and/or in providing a number of parallel cuts simultaneously. In the edible confectionery field, the market trend these days is towards lighter, softer and stickier products and not only are such products difficult to cut but, in addition, they produce a lot of waste. For example, sticky materials such as caramel or composite materials which are composed of different materials having different viscosities or hardness, e.g. confectionery products comprising a mixture of two or more of chocolate, nougat, caramel and nuts, tend to drag causing the product to lift before passing through the cutting blade, or bend the cutting blade giving a product of uneven width and which is overheated. Difficulty is also experienced in cutting materials which are brittle or friable, e.g. honeycomb or crystalline materials which may shatter if dropped. Often the cutting blades are not sufficiently reliable for long term production use.

[0003] In our co-pending EP-A-0943405, we describe and claim an ultrasonic cutting system which significantly reduces the above problems and difficulties. The ultrasonic cutting system claimed comprises an ultrasonic vibrating device having an operative face, a block horn having a responsive face connected to the operative face of the ultrasonic vibrating device and an operative face, and a plurality of cutting blades mounted on the operative face of the block horn so as to be vibrated thereby/therewith, the blades lying in a plane containing the longitudinal axis of vibrations characterised in that the block horn is provided with at least one tuning slot traversing the block horn between the operative and responsive faces. In this patent application, it is stated that the width of the tuning slots may be from 4 to 6mm.

[0004] However, we have found that, when using the system in EP-A-0943405 in practice, the fatigue life of the blades is not satisfactory. The ultrasonic system is essentially a resonant structure with enough inherent damping to control the vibrational amplitude. The cut material acts as a damping medium and will stabilize the cutting blades. The main problem is the behaviour of the system when it is removed from the product and is run in air. The transient force applied to the blades when removed,can cause the system to 'mode hop' i.e. change from a longitudinal mode of vibration at 36kHz to a lateral or flexural mode at some lower sub-harmonic. This lateral or flexural mode can be very destructive. The tip amplitude can change from 65 microns to 1 or 2mm. The extreme acceleration forces can cause the blade to fracture within seconds.

SUMMARY OF THE INVENTION

[0005] We have now surprisingly found that by including at least one thin tuning and damping slot having a width of from 0.1 to 2.5mm in addition to the wider tuning slots described in our copending patent application (hereinafter referred to as the "normal tuning slots"), the fatigue life of the blades is significantly increased, e.g the blades can run for 4 months or more in continuous operation.

[0006] Accordingly, the present invention provides an ultrasonic cutting system comprising an ultrasonic vibrating device having an operative face, a block horn having a responsive face connected to the operative face of the ultrasonic vibrating device and an operative face and being provided with at least one normal tuning slot traversing the block horn between its operative and responsive faces having a width from 4 to 6mm, a plurality of cutting blades mounted on the operative face of the block horn so as to be vibrated thereby/therewith, the blades lying in a plane containing the longitudinal axis of vibrations characterised in that the block horn is also provided with at least one thin tuning and damping slot having a width of from 0.1 to 2.5mm traversing the block horn between its operative and responsive faces.

DETAILED DESCRIPTION OF THE INVENTION

[0007] The ultrasonic vibrating device may be, for instance, a piezo-electric sandwich type transducer producing sinusoidal motion secured to the responsive face of the block horn either directly or indirectly through a booster device.

[0008] The block horn is preferably made of aluminium or titanium. The length of the block horn between the operative and responsive faces may be from 60 to 70mm, the breadth of the operative and responsive faces may be from 60 to 70mm, and the thickness through which the tuning slots traverse may be from 15 to 25mm.

[0009] One of the problems that may occur is the destabilisation of the cutting system due to distortion of the block horn. The distortion occurs wherein the outer edge of the operative face has about 20% more amplitude than the centre of this face. In order to reduce distortion, the block horn may advantageously be provided with a shoulder on its responsive face, e.g. a shoulder on each side which may, if desired, be stepped. The dis-

tortion can be reduced to about 5% or less in order to stabilise the cutting system.

[0010] The number of cutting blades mounted on the operative face of the block horn may be from 2 to 6 and preferably from 3 to 5. Advantageously, an odd number of cutting blades may be used, e.g. 3 or 5 cutting blades. A system composed of an odd number of elements, i. e., transducer, block horn and blade has an advantageous effect. The cutting blades are preferably made of steel.

[0011] The cutting blade frequency is preferably from 10 to 60kHz and the amplitude of the cutting blade is preferably from 20-250microns, preferably from 40 to 200microns. The cutting blade is preferably detuned to a value sufficiently different to that of the operative face of the block horn to stabilise the system and reduce the gain and slightly widen the frequency of operation of the system, e.g. by from 80 to 120Hz and preferably from 90 to 110Hz on either side of the frequency of operation. The blade is then machined to set the orientation of the individual blade so that the blades are parallel with each other and correctly aligned with the operative face of the block horn.

[0012] The length of the blades may be from 50 to 100mm and preferably from 70 to 80mm. The breadth of the blades may be from 5 to 20mm and preferably from 10 to 15mm. The thickness of the blades may be from 1.4 to 3.5 mm, preferably from 1.5 to 3.0mm and more preferably from 1.6 to 2.4mm. The distance apart of the blades may be from 15 to 35mm and preferably from 20 to 26mm. The cutting blade may be provided with a shoulder which is preferably clamped against the operating face of the block horn. The shoulder may have a length of from 25 to 45mm and preferably from 30 to 35mm. The width of the shoulder may be from 10 to 15mm. The shoulder of the cutting blade is advantageously provided with spanner slots in its front and rear faces which provide the means for tightening the blade to the operative face of the block horn.

[0013] The blades may be positioned on a vertical axis but are preferably positioned offset relative to the vertical axis, for instance, at an angle of from 5° to 20° and preferably from 10° to 15°.

[0014] The number of normal tuning slots is preferably one less than the number of cutting blades. The normal tuning slots are preferably offset relative to a pair of blades in a longitudinal plane. The size of the normal tuning slots may be chosen to reduce or eliminate transverse vibrations and reduce distortion of the block. For instance, the normal tuning slots may have a length of from 20 to 60mm, preferably from 30 to 50mm and more preferably from 35 to 45mm. The width of the normal tuning slots is preferably from 4.5 to 5.5mm.

[0015] The thin tuning and damping slots preferably have a width of from 0.15 to 1 mm, more preferably from 0.2 to 0.75mm, and even more preferably from 0.25 to 0.6mm. The length of the tuning and damping slots is advantageously less than the length of the normal tuning slots and may be, for instance, from 10 to 50mm, preferably from 20 to 40mm and more preferably from 25 to 35mm.

[0016] Advantageously, from one to four thin tuning slots are positioned between a pair of normal tuning slots and preferably two or three thin tuning slots are positioned between a pair of normal tuning slots, i.e. in the same longitudinal plane as the blades. When two or more thin tuning slots are positioned between a pair of normal tuning slots, they may be spaced apart by from 0.1 to 10mm, preferably from 1 to 8mm, more usually from 2 to 6mm.

[0017] It should be understood in this invention that the dimensions, e.g. of the blades, normal tuning slots and the thin tuning and damping slots are normally correspondingly larger for lower frequencies and vice versa.

[0018] Each part of the block horn carrying a blade is referred to as a limb and we have found that making the two outer limbs of the block horn wider than the central portion aids the stability of the structure. We have found that three identical limbs in a block horn can sometimes act as resonant structures and effectively work as a tuning fork causing unacceptably high amplitudes within the block horn. For example, in a block horn with three limbs, the two outer limbs may be 19mm and the central one 16mm, slots at 5mm each making an overall width of 64mm.

[0019] If desired, a plurality of ultrasonic cutting systems according to this invention may be connected in series to increase the number of cutting blades, e.g. from 5 to 10 cutting systems in series to provide a total number of blades of from 20 to 40.

[0020] The present invention also provides an apparatus for cutting a material comprising an ultrasonic vibrating device having an operative face, a block horn having a responsive face connected to the operative face of the ultrasonic vibrating device and an operative face and being provided with at least one normal tuning slot having a width of from 4 to 6mm traversing the block horn between its operative and responsive faces, a plurality of cutting blades mounted on the operative face of the block horn so as to be vibrated thereby/therewith, the blades lying in a plane containing the longitudinal axis of vibrations, means for conveying the material to be cut, and means for causing the cutting blades to be ultrasonically vibrated while moving said cutting blades in said plane through said material characterised in that the block horn is also provided with at least one thin tuning and damping slot having a width of from 0.1 to 2.5mm traversing the block horn between its operative and responsive faces.

[0021] The means for providing support for the material to be cut as it passes through the cutting head may be a conveyor belt which supports the material, e.g. an upper guide belt and a lower conveyor belt or individual "V" belts which effectively sandwich the material as it is conveyed.

[0022] The present invention further provides a method of cutting a material which comprises conveying the material beneath an ultrasonic cutting system comprising an ultrasonic vibrating device having an operative face, a block horn having a responsive face connected to the operative face of the ultrasonic vibrating device and an operative face, and being provided with at least one normal tuning slot having a width of from 4 to 6mm traversing the horn between its operative and responsive faces, a plurality of cutting blades mounted on the operative face of the block horn so as to be vibrated thereby/therewith, the blades lying in a plane containing the longitudinal axis of vibrations, and causing the cutting blades to be ultrasonically vibrated while moving said cutting blades in said plane through said material, characterised in that the block horn is also provided with at least one thin tuning and damping slot having a width of from 0.1 to 2.5mm traversing the block horn between its operative and responsive faces.

[0023] The material is conveniently transported beneath the ultrasonic cutting system on a conveyor belt. The speed of the material may be up to 10 metres/min, for instance, from 1 to 8 metres/min and preferably from 2 to 6 metres/min.

[0024] Advantageously, the material to be cut is transported beneath the ultrasonic cutting system between an upper guide belt and a lower conveyor belt which effectively sandwich the material as it is conveyed. The use of upper and lower conveyor belts which effectively sandwich the material substantially prevents the tendency of the material to lift up as it passes through the cutting blades due to the drag of the blades. This tendency is more pronounced when more cutting blades are used in the system.

[0025] The material may be a sticky material, a brittle or friable material or a composite material composed of different materials having different viscosities or hardness. Suitable materials which may be cut by the ultrasonic cutting system of this invention are, e.g. confectionery products comprising one or a mixture of two or more of chocolate, nougat, caramel, nuts, bakery products, snack products, meals, filled dough products, ice cream, and combinations thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The present invention will now be further illustrated with reference to the accompanying drawings in which

Figure 1 represents a plan view of an ultrasonic cutting system of the invention,

Figure 2 represents a diagrammatic side view of the ultrasonic cutting system of the invention cutting a nougat material, and

Figure 3 represents a section through the line B-B of Figure 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0027] Referring to the drawings, Figure 1 shows a transducer/booster assembly 10 to which is attached a block horn 11 provided with two normal tuning slots 12 having a length of 40mm and a width of 4mm, and thin tuning and damping slots 13 having a length of 31.5mm and a width of 0.5mm each member of a pair being spaced 4mm apart. Attached to the block horn are cutting blades 14 each provided with a cutting edge 15.

[0028] Figures 2 and 3 show the nougat material 16 being transported on a conveyor belt 17 in the direction of the arrow and then sandwiched between a lower drive belt 18 and an upper guide belt 19 where it passes beneath the ultrasonic cutting system comprising the block horn 11 and cutting blades 15, the cutting blades being ultrasonically vibrated while passing vertically downwards through the nougat material to cut it, the cut nougat material being finally transported away on conveyor belt 20.

[0029] The fatigue life of the blades using the tuning and damping slots having a width of 0.5mm was found to be at least 4 months during continuous operation.

Claims

1. An ultrasonic cutting system comprising an ultrasonic vibrating device having an operative face, a block horn having a responsive face connected to the operative face of the ultrasonic vibrating device and an operative face and being provided with at least one normal tuning slot having a width of from 4 to 6mm traversing the block between its operative and responsive faces, a plurality of cutting blades mounted on the operative face of the block horn so as to be vibrated thereby/therewith, the blades lying in a plane containing the longitudinal axis of vibrations characterised in that the block horn is also provided with at least one thin tuning and damping slot having a width of from 0.1 to 2.5mm traversing the block horn between its operative and responsive faces.

2. An ultrasonic cutting device according to claim 1 wherein the length of the block horn between the operative and responsive faces is from 60 to 70mm, the breadth of the operative and responsive faces is from 60 to 70mm, and the thickness through which the tuning slots traverse is from 15 to 25mm.

3. An ultrasonic cutting device according to claim 1 wherein the the block horn is provided with a shoulder on its responsive face.

4. An ultrasonic cutting device according to claim 1 wherein the the block horn is provided with a shoulder on each side of its responsive face.

5. An ultrasonic cutting device according to claim 1 wherein the the block horn is made of aluminium or titanium.

6. An ultrasonic cutting device according to claim 1 wherein the number of cutting blades mounted on the operative face of the block horn is from 2 to 6.

7. An ultrasonic cutting device according to claim 1 wherein an odd number of cutting blades is used.

8. An ultrasonic cutting device according to claim 1 wherein the cutting blade is detuned to a value from 80 to 120Hz different to that of the operative face of the block horn.

9. An ultrasonic cutting device according to claim 1 wherein the cutting blade frequency is from 10 to 60kHz and the amplitude of the cutting blade is from 20-250microns.

10. An ultrasonic cutting device according to claim 1 wherein the cutting blade is detuned to a value sufficiently different to that of the operative face of the block horn to stabilise the system and reduce the gain and slightly widen the frequency of the operation and then machined to set the orientation of the individual blade.

11. An ultrasonic cutting device according to claim 1 wherein the length of the blades is from 50 to 100mm, the thickness of the blades is from 1.4 to 3.5mm and the distance apart of the blades is from 15 to 35mm.

12. An ultrasonic cutting device according to claim 1 wherein the cutting blades are positioned offset relative to the vertical axis.

13. An ultrasonic cutting device according to claim 1 wherein the number of tuning slots is one less than the number of cutting blades.

14. An ultrasonic cutting device according to claim 1 wherein the tuning slots are offset relative to a pair of blades in a longitudinal plane.

15. An ultrasonic cutting device according to claim 1 wherein the tuning and damping slots have a width of from 0.2 to lmm.

16. An ultrasonic cutting device according to claim 1 wherein a plurality of ultrasonic cutting systems according to this invention are connected in series to increase the number of cutting blades to from 5 to 10 cutting systems in series to provide a total number of blades of from 20 to 40.

17. An apparatus for cutting a material comprising an ultrasonic vibrating device having an operative face, a block horn having a responsive face connected to the operative face of the ultrasonic vibrating device and an operative face and being provided with at least one normal tuning slot traversing the block horn between its operative and responsive faces having a width of from 4 to 6mm, a plurality of cutting blades mounted on the operative face of the block horn so as to be vibrated thereby/therewith, the blades lying in a plane containing the longitudinal axis of vibrations, means for conveying the material to be cut, and means for causing the cutting blades to be ultrasonically vibrated while moving said cutting blades in said plane through said material characterised in that the block horn is also provided with at least one thin tuning and damping slot having a width of from 0.1 to 2.5mm traversing the block horn between its operative and responsive faces.

18. An apparatus according to claim 17 wherein the means for conveying the material to be cut is a conveyor belt which supports the material.

19. An apparatus according to claim 17 wherein the means for conveying the material to be cut comprises an upper and lower conveyor belt which effectively sandwich the material as it is conveyed.

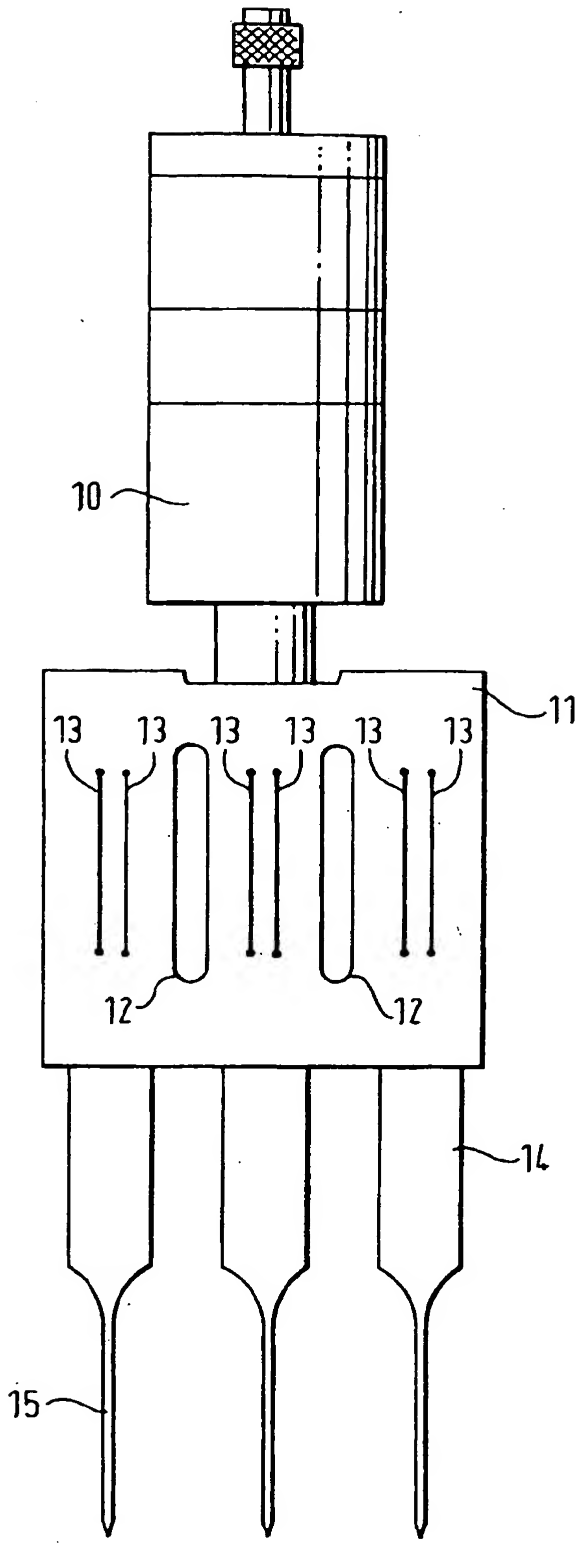
20. A method of cutting a material which comprises conveying the material beneath an ultrasonic cutting system comprising an ultrasonic vibrating device having an operative face, a block horn having a responsive face connected to the operative face of the ultrasonic vibrating device and an operative face, and being provided with at least one normal tuning slot traversing the horn between its operative and responsive faces having a width of from 4 to 6mm, a plurality of cutting blades mounted on the operative face of the block horn so as to be vibrated thereby/therewith, the blades lying in a plane containing the longitudinal axis of vibrations, and causing the cutting blades to be ultrasonically vibrated while moving said cutting blades in said plane through said material, characterised in that the block horn is also provided with at least one thin tuning and damping slot having a width of from 0.1 to 2.5mm traversing the block horn between its operative and responsive faces.

21. A method according to claim 20 wherein the material is transported beneath the ultrasonic cutting system on a conveyor belt at a speed of up to 10

metres/min.

22. A method according to claim 20 wherein the material to be cut is transported beneath the ultrasonic cutting system between upper and lower conveyor belts which effectively sandwich the material as it is conveyed.

FIG. 1



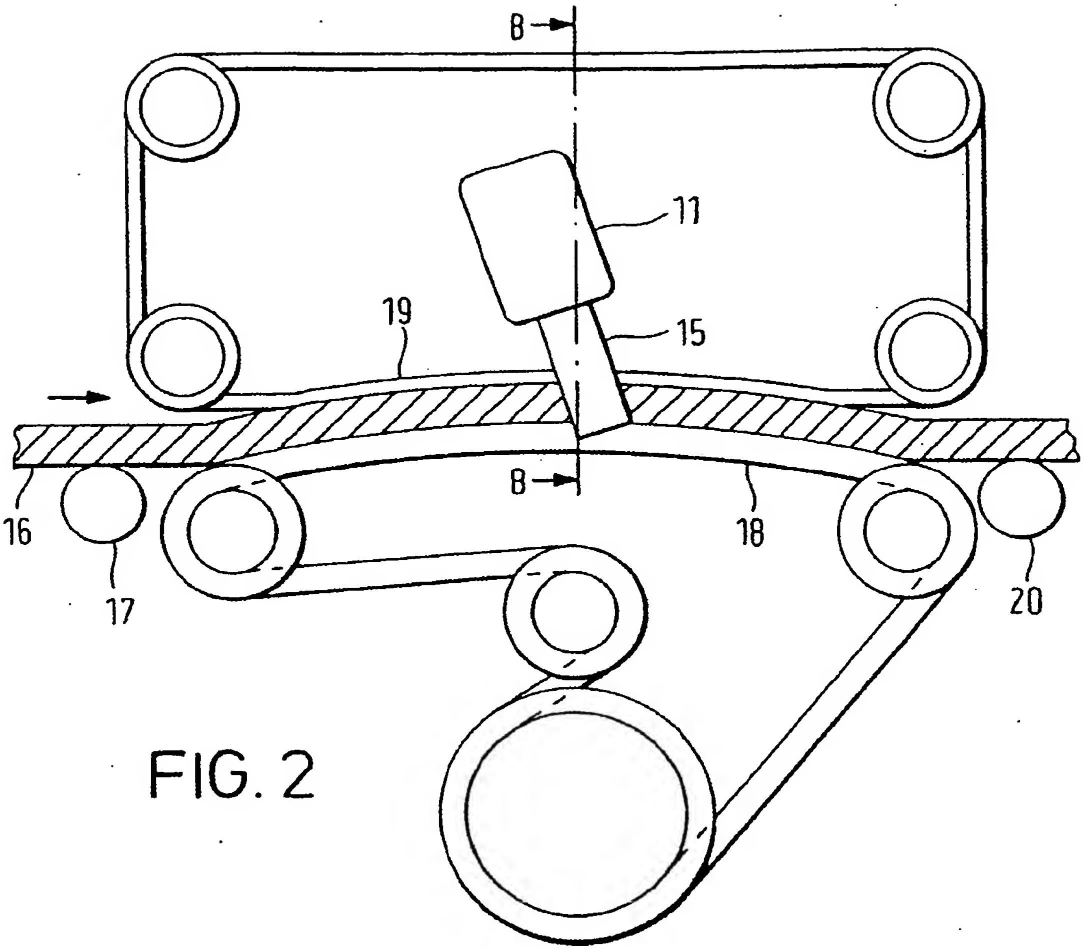


FIG. 2

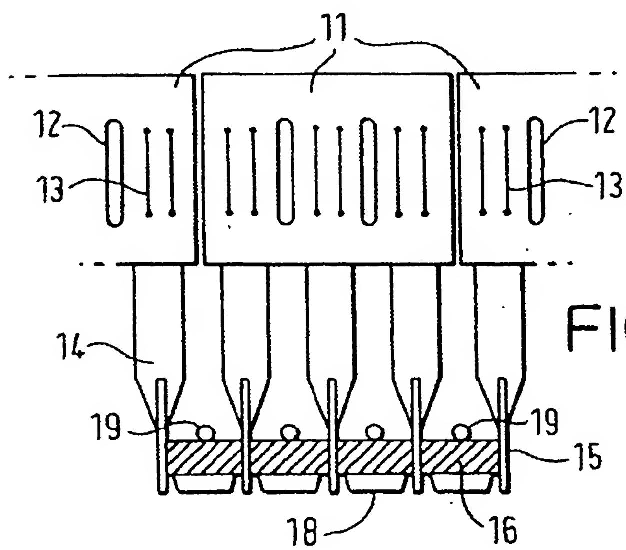


FIG. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 20 3297

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A,D	EP 0 943 405 A (NESTLE SA) 22 September 1999 (1999-09-22) * the whole document * ---	1-22	B26D7/08
A	PATENT ABSTRACTS OF JAPAN vol. 014, no. 367 (M-1008), 9 August 1990 (1990-08-09) & JP 02 131922 A (CHIYOUONPA KOGYO KK), 21 May 1990 (1990-05-21) * abstract * -----	1-22	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
B26D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	13 March 2001	Müller, A

CATEGORY OF CITED DOCUMENTS

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